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(19)

(54) APPARATUS FOR EXPOSING A PHOTOSENSITIVE LAYER THROUGH A MASK

(71) We, INTERNATIONAL BUSINESS MACHINES CORPORATION, a Corporation organized and existing under the laws of the State of New York in the United States of America, of Armonk, New York 10504, United States of America, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention relates to an apparatus for exposing a photo sensitive layer through a mask. The invention is applicable to the manufacture of semiconductor integrated circuits.

One method for exposing photo sensitive layers through masks is known as " proximity printing ", wherein the mask and the photo sensitive layer either touch or almost touch. With very narrow mask slits or openings such as are used in the manufacture of integrated circuits interference patterns occur by diffraction at the slits, reducing the definition of the exposure. It is known that the defects resulting from diffraction at the narrow mask slits can be reduced by exposing with at least two light beams at a small angle to one another. The angle between the two beams is selected in such a manner that the diffraction patterns generated by beams on the narrow mask slits are staggered in relation to one another in the plane of the photosensitive layer by half the distance of two adjacent side maxima. In consequence the main maxima still largely overlap each other, thus being intensified, whereas the side maxima generated by one beam coincide with the side minima generated by the other beam.

At present, apparatus for performing the above method of exposure do not allow the angle between the two light beams to be varied as might be necessary for different mask slit widths.

According to the present invention, there is provided apparatus for exposing a photosensitive layer through a mask, comprising a source of light and an optical system for directing light from the source through the mask, the optical system including two prisms through which the light passes in succession, one prism being rotatable with respect to the other so as to vary the overall deflection of the light by the two prisms for varying the angle between the direction of incident light on the mask and the normal to the mask, and means to rotate the two prisms as a whole about an axis normal to the mask for directing the light through the mask from at least two different directions for any given said angle.

An embodiment of the invention will now be described with reference to the accompanying drawings, in which:

Fig. 1 is a schematic representation of the interference patterns occurring as a result of narrow mask openings;

Fig. 2 shows an apparatus for exposing through a mask from two different directions; and

Figs. 3 and 4 are lateral and plan views of a prism holder that can be used in the appartus of Fig. 2.

Fig. 1 shows the interference pattern which is generated when a light-sensitive layer is exposed through a mask. The arrangement depicted in this figure comprises a mask 2 which consists of a transparent support 3 and the actual mask layer 4. Under the mask a semiconductor wafer 8 is arranged which is coated with a light-sensitive photoresist 7. The interference pattern generated by the radiation 1*a* is represented by line 12, whereas the interference pattern generated by the radiation 1*b* is represented by line 13. It will be apparent that with the radiation 1*a* and 1*b* propogating in the same direction the resulting interference patterns 12 and 13

would fully overlap each other, which in practice would lead to a doubling of the the main and side maxima. The resulting amplitude of the side maxima would be above the line designated as 0.5 and representing the intensity required for full exposure of the photoresist. By exposing with at least two radiations of identical intensity but which form a small angle with each other, the diffraction patterns caused by the interference on the apertures 5 can be shifted in relation to each other by half the distance between two adjoining side maxima, whereupon the resulting intensities of the side maxima are substantially weakened and the intensity of the main maximum is almost doubled.

Fig. 2 shows an apparatus based upon a known way of providing illumination of a photoresist from different directions. The apparatus comprises a light source 21, a condenser lens 22, a mirror 23, and a prism holder 26 rotatable perpendicularly to the direction of the radiation 24. The prism holder is provided with a gearing 27. Via gears 28,29 and 30 and an electric motor 31, the prism holder can be rotated about an axis of rotation, not shown, which extends parallel to the radiation 24. It will be seen that the prism 32 causes the centre axis 25 of the radiation 24 to move around the surface of a cone 35 of angle ϕ. The angle ϕ is fixed and, since the optimum value of ϕ depends upon the fineness of the mask pattern (mask slit width) the prism must be changed when the mask is changed for one having a different pattern fineness.

Fig. 3 and 4 show a prism holder 26 which can be substituted in the apparatus of Fig. 2 and enables the deflection angle of the radiation to be adjusted throughout a continuous range. This prism holder comprises a ring 43 rotatable via means not shown about the centre axis 25 of the radiation and in which a prism 32 is mounted. The outer side of the ring 43 is provided with a gearing 27 and its inner side has a recess 44 in which a ring 42, accommodating a prism 33, is rotatably mounted. On the upper side of the prism holder 26 scales 45, 46 and 47 and pointers 48, 49 and 50, acting in combination with the latter, are arranged. The effect of the two prisms is as follows: for the sake of simplicity, it is assumed that the two prisms 32 and 33 are identical and effect the same individual deflection. In this case a maximum deflection will occur when the prisms are similarly oriented, as shown in the figure, whereas with an opposite orientation no directional deflection of the radiation 24 will result.

The relative orientation of the prisms is effected by rotating the ring 42 relative to the ring 43. The scales 45, 46 and 47 on the upper side of the rings 42 and 43 indicate the relative angular position of the prisms at a particular setting, the radiation deflection corresponding to the relative angular position of the prisms, and the mask slit width for which the setting is an optimum. Thus, the scale 45 on ring 42 and the pointer 48 on ring 43 permit each relative position from 0 to 180° to be set between the two prisms, whereas scale 46 on ring 42 and pointer 49 on ring 43 permit setting the deflection angle between 0 and 10°. By means of the scales 47 on the outer ring 43 and the pointer 50 on the inner ring 42, the arrangement can be set directly to the slid width of the mask employed. It is, of course, possible to provide prism holder 26 with further scales for other parameters. The scales shown in Fig. 4 are not computed values. This figure is rather used to explain how the scales are employed.

Thus, it is possible to change from masks with one slit width to masks with other slit widths, without changing optical components. The prism holder 26 is so small that it can be inserted into the path of most known exposure arrangements without rebuilding or special design measures.

WHAT WE CLAIM IS:—

1. Apparatus for exposing a photosensitive layer through a mask, comprising a source of light and an optical system for directing light from the source through the mask, the optical system including two prisms through which the light passes in succession, one prism being rotatable with respect to the other so as to vary the overall deflection of the light by the two prisms for varying the angle between the direction of incident light on the mask and the normal to the mask, and means to rotate the two prisms as a whole about an axis normal to the mask for directing the light through the mask from at least two different directions for any given said angle.

2. Apparatus as claimed in claim 1, substantially as described with reference to the accompanying drawings.

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1 459 719 COMPLETE SPECIFICATION
3 SHEETS

This drawing is a reproduction of the Original on a reduced scale.
SHEET 1

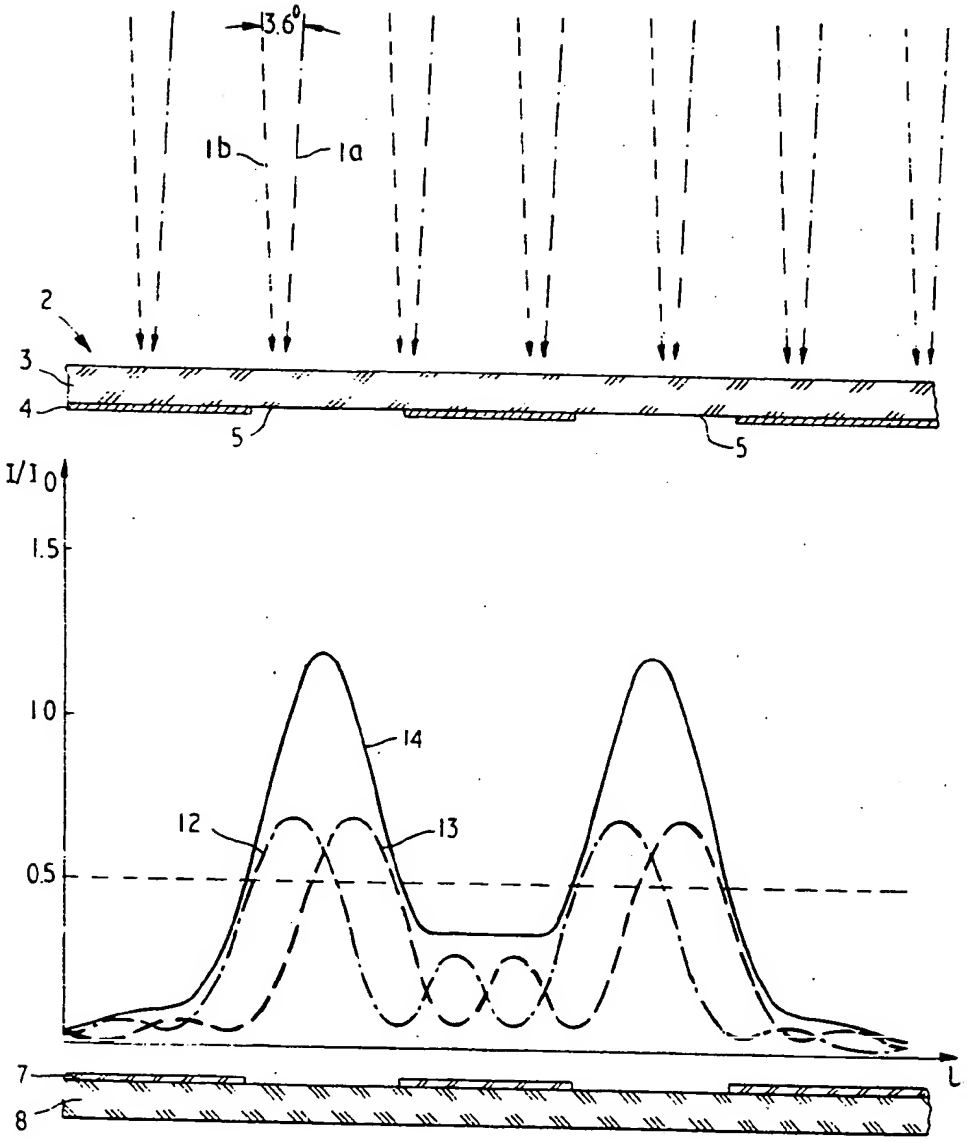

FIG 1

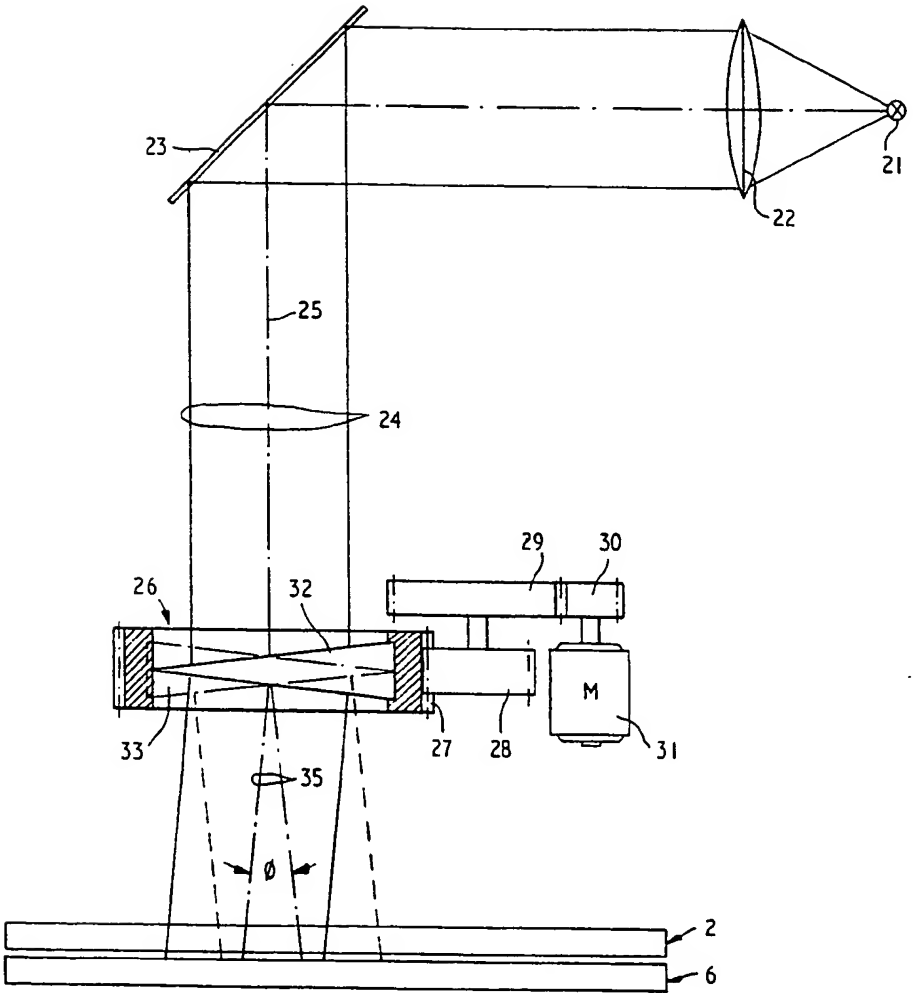

FIG. 2

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3 SHEETS

COMPLETE SPECIFICATION

SHEET 3

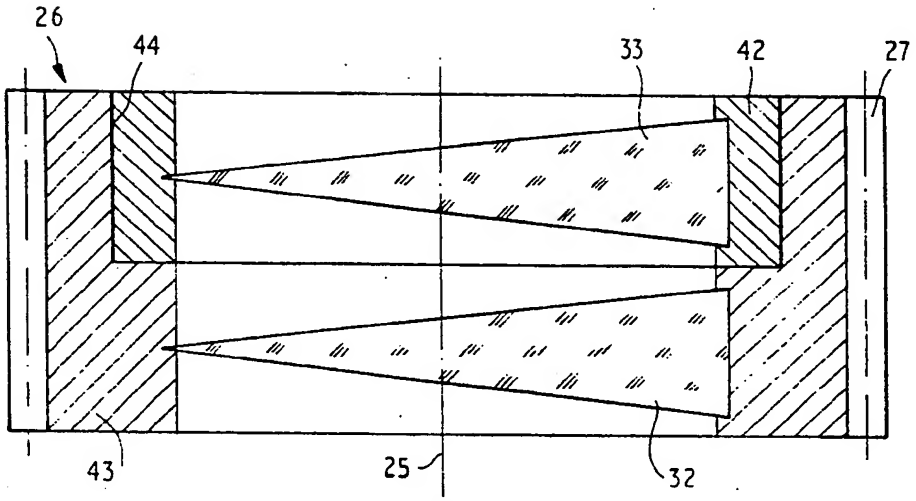

FIG 3

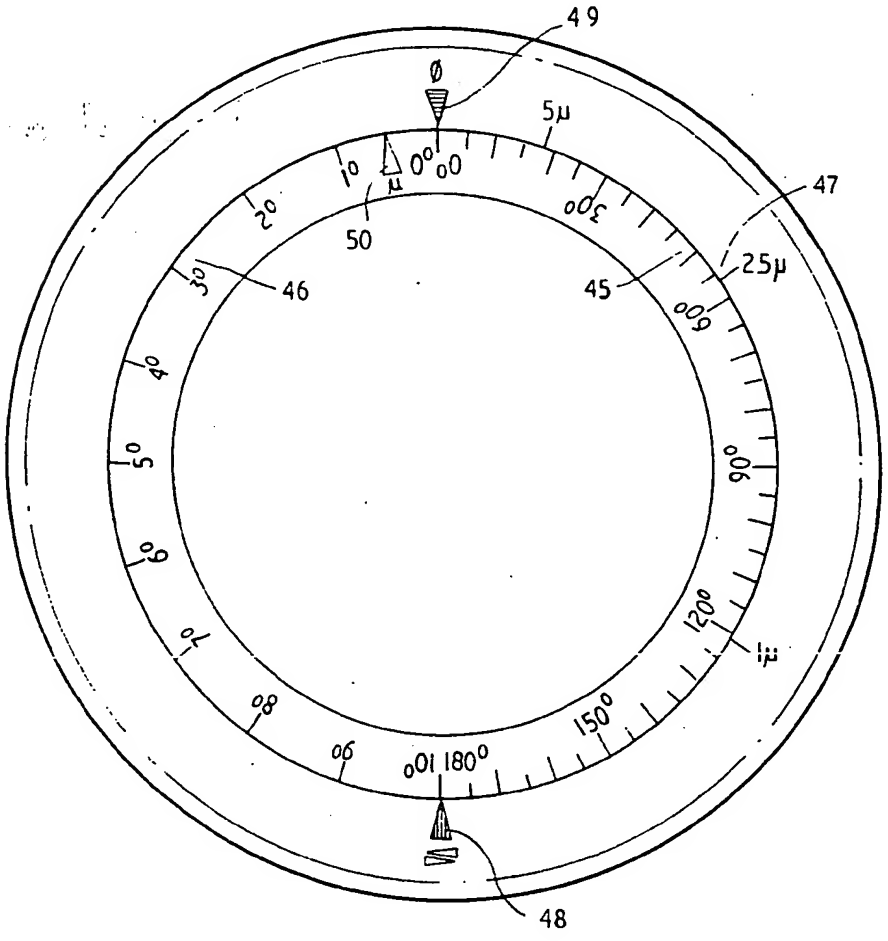

FIG 4